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(54) **SYSTEM AND METHOD FOR ADAPTIVE CHANNEL SCANNING WITHIN A WIRELESS NETWORK**

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H04W 88/08	(2009.01)

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CPC *H04W 8/005* (2013.01); *H04W 28/0215* (2013.01); *H04W 28/04* (2013.01); *H04W 84/12* (2013.01); *H04W 88/08* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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(57) **ABSTRACT**

An access point device that is adapted to a wireless network and a wired network is disclosed. The access point includes a transceiver to receive wireless frames from a plurality of wireless devices of the wireless network, respectively, and at least one component to process information extracted from the wireless frames and to control channel scanning based upon at least one of an amount of wireless device traffic and a type of call.

36 Claims, 5 Drawing Sheets
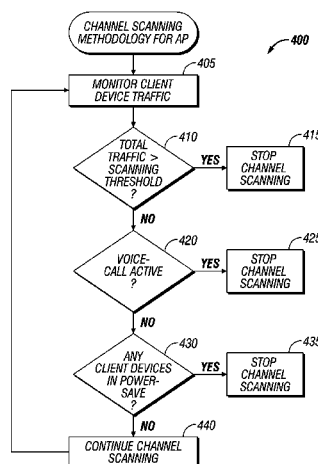
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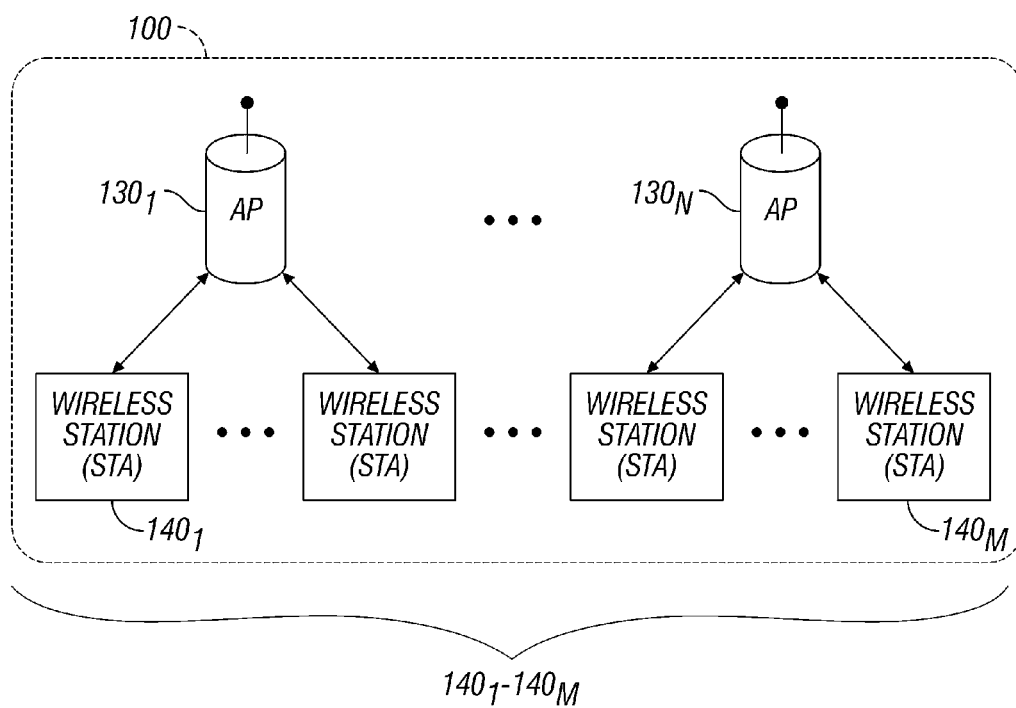
FIG. 1

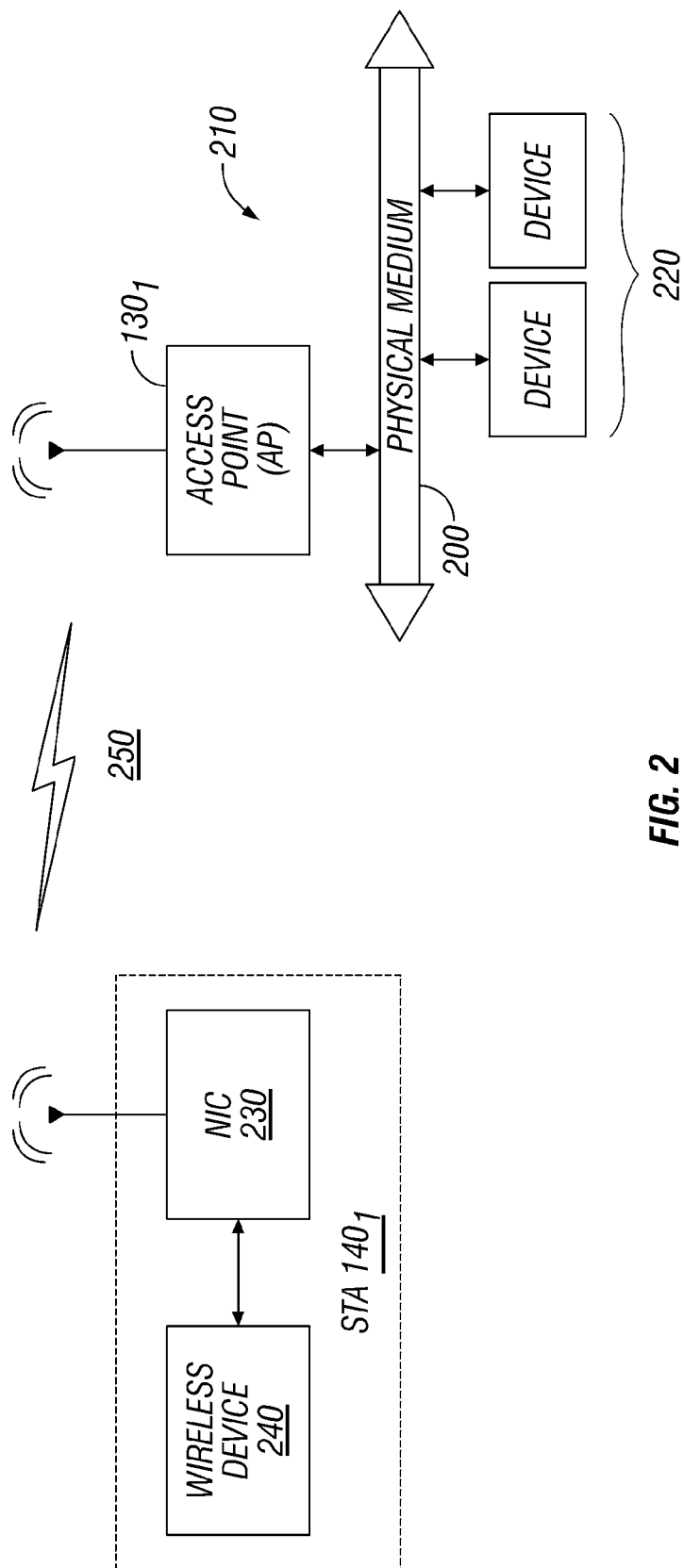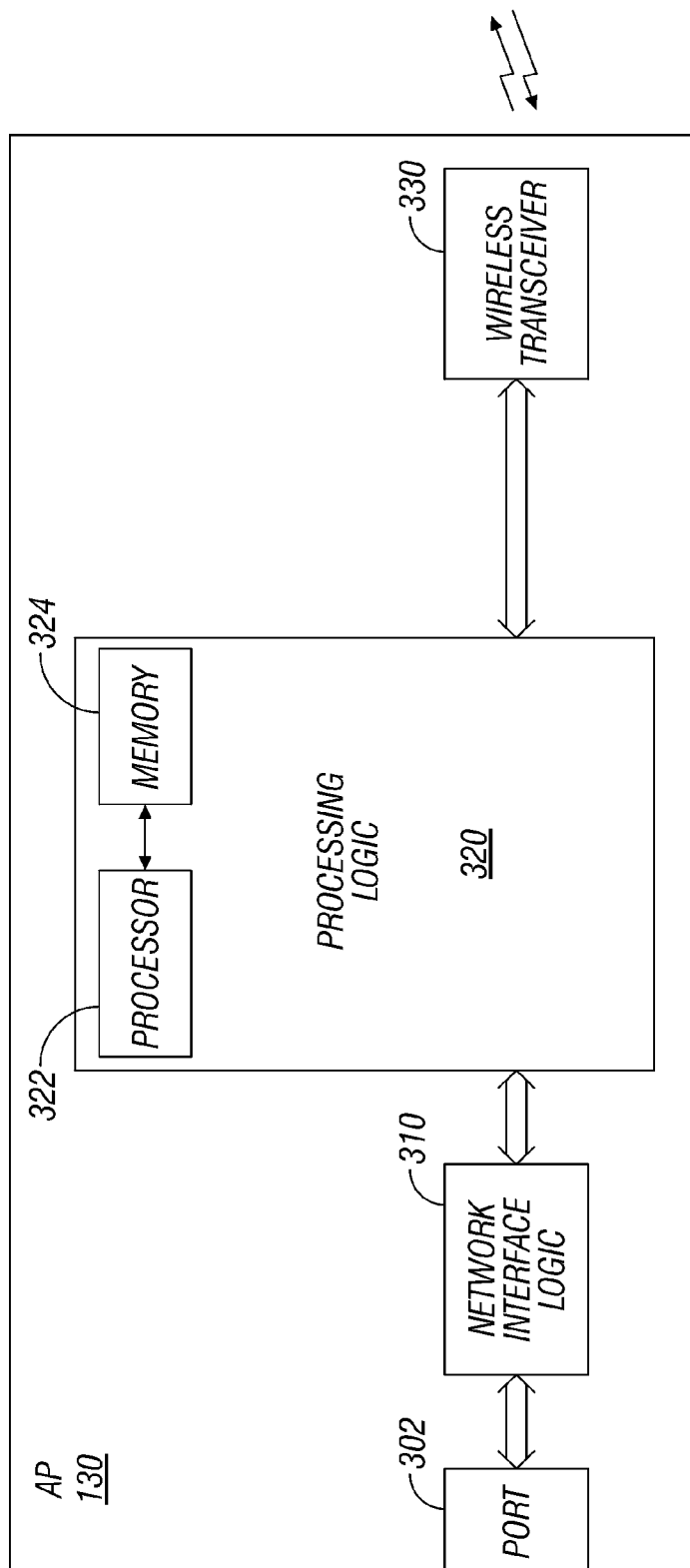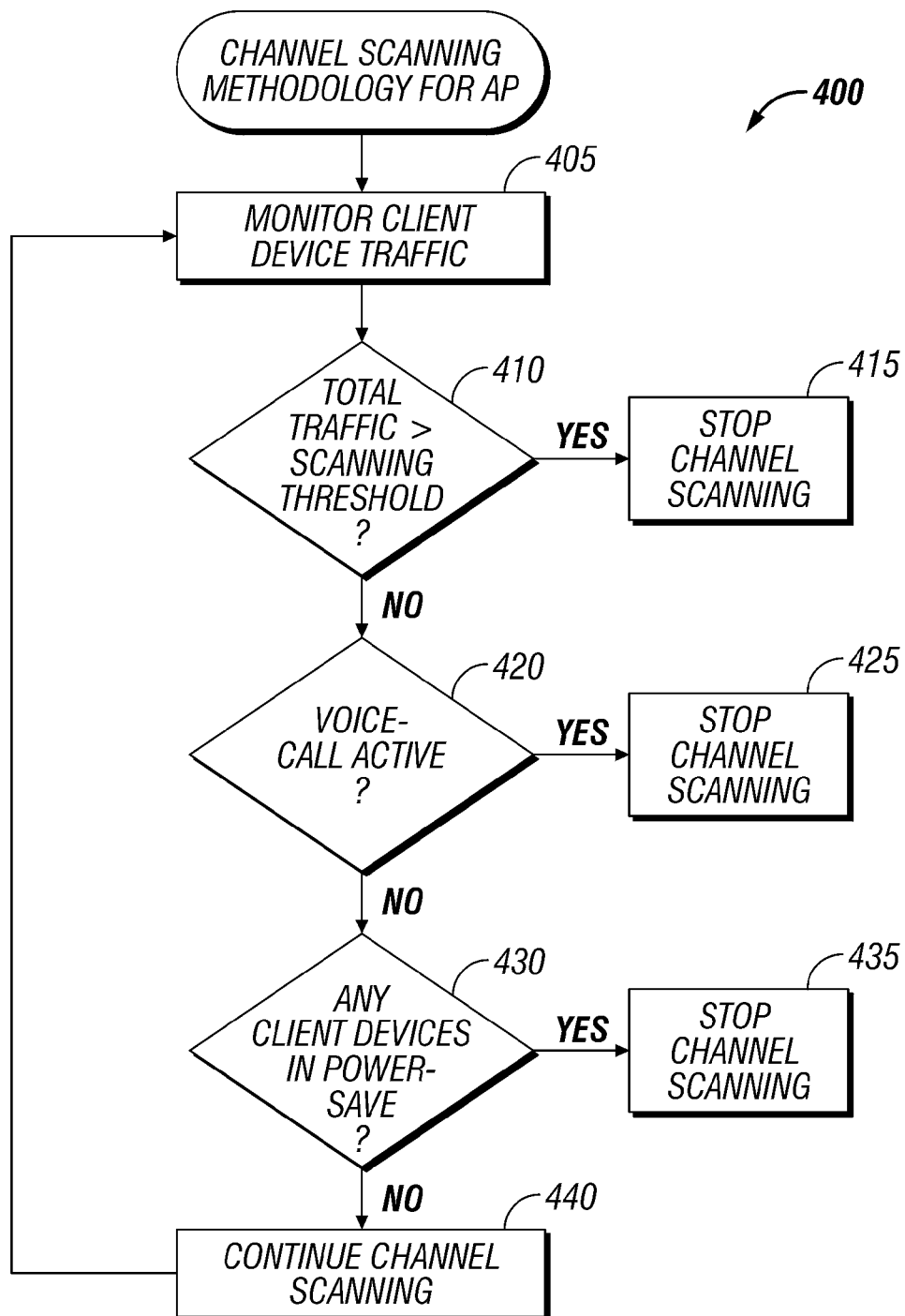*FIG. 2*
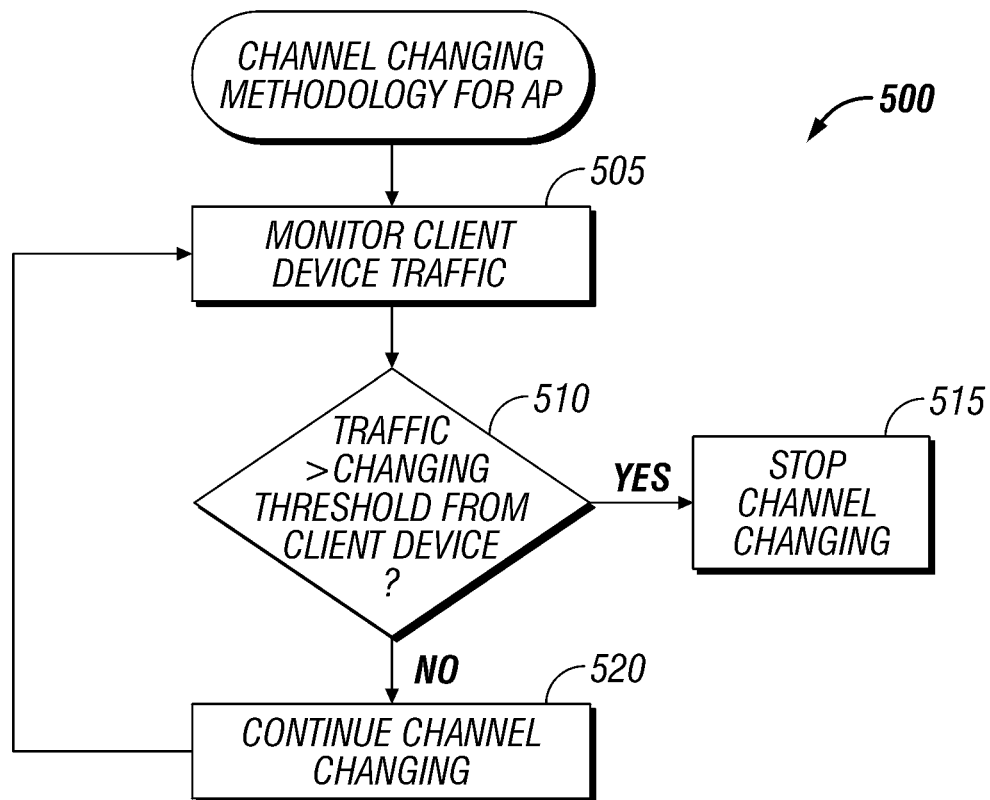
FIG. 3

FIG. 4

FIG. 5

SYSTEM AND METHOD FOR ADAPTIVE CHANNEL SCANNING WITHIN A WIRELESS NETWORK

PRIORITY CLAIM

Incorporation by Reference

This application claims priority as a Continuation of U.S. patent application Ser. No. 14/469,510 filed on Aug. 26, 2014, which claims priority as a Continuation of U.S. patent application Ser. No. 11/542,327 filed on Oct. 2, 2006, the entire content of both of which is hereby incorporated by reference.

FIELD

Embodiments of the invention relate to the field of wireless communications, and in particular, to a mechanism that provides for adaptive channel scanning within a wireless network.

GENERAL BACKGROUND

Over the last decade or so, for most businesses, it has become a necessity for employees to share data over an enterprise network featuring one or more local area networks. To improve efficiency, enhancements have been added to a local area network such as remote wireless access. This enhancement provides an important extension in forming a wireless local area network (WLAN).

Typically, a WLAN supports communications between wireless devices and Access Points (APs). In general, each AP operates as a relay station by supporting communications with both wireless devices being part of a wireless network and resources of a wired network.

In order to effectively service multiple wireless devices that receive and transmit information on different channels through the AP to other wireless devices and to the wired network, APs typically perform some sort of channel scanning functionality. Typically, the AP will periodically scan other channels, to measure coverage and interference characteristics.

However, when the AP is scanning other channels, it cannot service wireless devices on its current operating channel. Present methods for channel scanning employed by APs are inefficient in that they do not take into the amount and type of wireless traffic in making channel scanning decisions.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may best be understood by referring to the following description and accompanying drawings that are used to illustrate embodiments of the invention.

FIG. 1 is a diagram illustrating an exemplary embodiment of a wireless local area network (WLAN) in which embodiments of the invention may be practiced.

FIG. 2 is a diagram illustrating an exemplary embodiment of an Access Point of the WLAN of FIG. 1 in communication with a wireless station for use in an enterprise network.

FIG. 3 is a diagram illustrating a particular exemplary embodiment of an AP.

FIG. 4 is flowchart of operations for adaptive channel scanning for an access point within a wireless network, according to one embodiment of the invention.

FIG. 5 is a flowchart of operations for adaptive channel changing for an access point within a wireless network, according to one embodiment of the invention.

DETAILED DESCRIPTION

Embodiments of the invention relate to a system and method for adaptive channel scanning within a wireless network. In one embodiment, an access point device adapted to a wireless network and wired network implements adaptive channel scanning operations

The access point device may include a transceiver that receives wireless frames from a plurality of wireless devices of the wireless network, respectively, and at least one component to process information extracted from the wireless frames. More particularly, the access point device may control channel scanning based upon at least one of an amount of wireless device traffic and a type of call, as will be described in detail hereinafter.

Herein, the invention may be applicable to a variety of wireless networks such as a wireless local area network (WLAN) or wireless personal area network (WPAN). The WLAN may be configured in accordance with any Institute of Electrical and Electronics Engineers (IEEE) 802.11 standard such as an IEEE 802.11b standard entitled "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher-Speed Physical Layer Extension in the 2.4 GHz Band" (IEEE 802.11b, 1999), an IEEE 802.11a standard entitled "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: High-Speed Physical Layer in the 5 GHz Band" (IEEE 802.11a, 1999) or a revised IEEE 802.11 standard "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications" (IEEE 802.11, 1999). Of course, the invention may be compliant with systems configured in accordance with High Performance Radio Local Area Networks (Hiper-LAN) or subsequently published specifications.

Certain details are set forth below in order to provide a thorough understanding of various embodiments of the invention, albeit the invention may be practiced through many embodiments other than those illustrated. Well-known logic and operations are not set forth in detail in order to avoid unnecessarily obscuring this description.

In the following description, certain terminology is used to describe features of the invention. For example, a "component" includes hardware and/or software module(s) that are configured to perform one or more functions. For instance, a "processor" is logic that processes information. Examples of a processor include a microprocessor, an application specific integrated circuit, a digital signal processor, a micro-controller, a finite state machine, or even combinatorial logic.

A "software module" is executable code such as an operating system, an application, an applet or even a routine. Software modules may be stored in any type of memory, namely suitable storage medium such as a programmable electronic circuit, a semiconductor memory device, a volatile memory (e.g., random access memory, etc.), a non-volatile memory (e.g., read-only memory, flash memory, etc.), a floppy diskette, an optical disk (e.g., compact disk or digital versatile disc "DVD"), a hard drive disk, tape, or any kind of interconnect (defined below).

An "interconnect" is generally defined as an information-carrying medium that establishes a communication pathway. Examples of the medium include a physical medium (e.g., electrical wire, optical fiber, cable, bus traces, etc.) or a wireless medium (e.g., air in combination with wireless signaling technology).

"Information" is defined as data, address, control or any combination thereof. For transmission, information may be transmitted as a message, namely a collection of bits in a predetermined format. One particular type of message is a

frame including a header and a payload, each having a predetermined number of bits of information.

I. General Architecture

Referring to FIG. 1, an exemplary embodiment of a wireless network 100 for use in an enterprise network in which embodiments of the invention may be practiced is illustrated. Herein, wireless network 100 includes one or more Access Points (APs) 130_1-130_N (N≥1) and one or more wireless stations (STAs) 140_1-140_M (M≥1), which are in wireless communication with APs 130_1-130_N.

As shown in FIG. 2, each AP 130_1, . . . , or 130_N supports bi-directional communications by (i) receiving data frames and transmitting data from these frames onto a physical medium 200 that forms part of a wired network 210 and (ii) receiving data from wired network 210 and transmitting data frames to one or more targeted STAs 140_1, . . . , 140_M; to form a portion of the enterprise network.

Wired network 210 can be of any type of wired network, including but not limited or restricted to Ethernet, Token Ring, Asynchronous Transfer Mode (ATM) or the like. Moreover, wired network 210 features resources that are available for users of wireless network 100. Such resources may include devices 220 for data storage, which are coupled to physical medium 200.

STA 140_1 includes a removable, wireless network interface card (NIC) 230 that is separate from or employed within a wireless device 240 that processes information (e.g., computer, personal digital assistant "PDA", telephone, alphanumeric pager, etc.). Normally, NIC 230 comprises a wireless transceiver, although it is contemplated that NIC 230 may feature only receive (RX) or transmit (TX) functionality such that only a receiver or transmitter is implemented.

STA 140_1 communicates with and accesses information from AP 130_1 over the air 250 in accordance with IEEE 802.11 communications protocol or another wireless networking protocol. Hence, AP 130_1 generally operates as a transparent bridge connecting both a wireless network featuring STA 140_1 with wired network 210.

Each AP 130 scans different frequency channels and maintains information about the other APs 130_1-130_N and STAs 140_1-140_M in wireless network 100. Generally, each AP 130 monitors wireless network 100 to extract information from wireless frames. Examples of wireless frames include, but are not limited or restricted to IEEE 802.11 data frames, Beacon frames, HiperLAN frames or the like. This information may be used to influence the behavior of wireless network 100.

Referring to FIG. 3, an exemplary embodiment of an AP 130 is shown. AP 130 comprises port 302, network interface logic 310, processing logic 320, and wireless transceiver 330. Processing logic 320 may include a processor 322 and memory 324. As optional features, AP 130 may further comprise one or more additional ports (e.g., a second port) and corresponding wired interface logic to support wired communications with a client device in lieu of wireless communications over wireless transceiver.

According to the illustrated embodiment, port 302 is adapted for coupling with the data transfer device (not shown), and therefore, enables the receipt of messages from and the transmission of messages to the main network over interconnect 200 of FIG. 2.

Network interface logic 310 is configured as a combination of hardware and software to control the transmission and receipt of information at the physical (PHY) and data link (MAC) layers (also referred to as "OSI Layer 1 and OSI Layer 2").

For example, network interface logic 310 may be adapted as an Ethernet controller including or coupled with process-

ing logic 320. An Ethernet controller provides Internet connectivity and operates to extract information from incoming messages. The extracted information may include destination, source or intermediary addresses, payload data, management or control information, or the like. Similarly, an Ethernet controller may be adapted to insert information into outgoing messages as well.

Wireless transceiver 330 comprises an antenna, a power amplifier, and other circuitry to support the radio functionality. More specifically, for one embodiment of the invention supporting IEEE 802.11 communication standards, wireless transceiver 330 comprises an antenna to receive incoming wireless messages.

The wireless message(s) include IEEE 802.11 MAC frames encoded and carried within a frequency channel that is located within a carrier frequency band. The carrier frequency band is located within typical radio frequency (RF) band of frequencies. For example, the RF band may generally fall within an approximate range of 2.4-2.5 GHz or perhaps an approximate range of 5-5.25 GHz. It is contemplated, though, that the invention may be applied to any frequency range.

Wireless transceiver 330 isolates the frequency channel on which data is carried from all the other frequencies received on the antenna. This may be accomplished through a tunable filter tuned to a center frequency of a channel of interest. The data channel undergoes a frequency shifting from the carrier band to baseband and the baseband analog radio signal is routed to an analog-to-digital converter (ADC). The ADC samples the baseband analog radio signal and converts it into digital information, which is transferred to processor 320 and may be processed according to the operational flow set forth in FIGS. 4 and 5.

As previously described, utilizing wireless transceiver 330, each AP 130 scans different frequency channels and further within memory 324 of processing logic 320 may store information about the other APs 130_1-130_n and STAs 140_1-140_n (i.e. wireless devices) and wireless network 100. Generally, each AP 130 monitors wireless network 100 to extract information from wireless frames. Examples of wireless frames include, but are not limited or restricted to IEEE 802.11 data frames, beacon frames, HiperLAN frames are the like.

For example, the processing logic 320 of each AP 130 may extract and process information from received wireless frames and may store that information as data structures describing each of the other APs 130_1-130_n being monitored as well as the wireless devices 140_1-140_n being monitored in the wireless network. Such information is recovered from the wireless frames received by the AP 130.

For example, each AP, for each wireless device being monitored, may store a wireless device ID for the wireless device, a channel identifier identifying the channel upon which the identified wireless device is operating, the amount of wireless device traffic associated with the wireless device, as well as the type of communication (e.g. voice call, e-mail, etc.) from the wireless device.

Utilizing this type of information, the AP 130 can make intelligent choices in adaptive channel scanning between the wireless devices of the wireless network and the wired network. This adaptive channel scanning methodology will be hereinafter discussed with reference to FIGS. 4 and 5. Referring now to FIG. 4, a general flowchart of operations for adaptive channel scanning for an AP within a wireless network, according to one embodiment of the invention, is shown.

Initially, AP 130 monitors the wireless network for wireless client device traffic on a particular channel (Block 405). In this way, the AP 130 utilizing processing logic 320 may

process information extracted from wireless frames in order to control channel scanning based upon at least one of an amount of wireless device traffic and a type of call.

More specifically, as shown in process **400**, the AP monitors the amount of wireless device traffic for a given channel and if it is determined to be greater than a scanning threshold (Block **410**), then channel scanning is stopped (Block **415**). In particular, in one embodiment, the scanning threshold may be an approximately 500 frames of wireless device traffic within approximately one second period of time. In this instance, channel scanning is stopped because the channel is busy with wireless client device traffic and if channel scanning were continued data may be lost.

Next, process **400** moves on to decision block **420** where it is determined whether or not a voice call is active. If a voice call is active, then channel scanning is stopped. Because voice call frames occur approximately every 20 milliseconds, there is no time to continue channel scanning without a very significant chance of losing voice-call packets. Therefore, channel scanning is stopped and the AP remains tuned to the voice call channel.

Next, process **400** moves to decision block **430** where it is determined whether any of the wireless client devices being monitored are currently in a power-save mode. If so, channel scanning is stopped (Block **435**). This is because if scanning was continued and a wireless client device exited a power save mode to transmit information, the AP may miss the transmission.

Assuming none of the traffic, voice call or power-save conditions are true then the AP will continue with channel scanning (Block **440**) and will also monitor for client device traffic (Block **405**) and continue employing process **400**.

The above methodology increases the efficiency of the wireless network because channel scanning is stopped when a condition exists that may result in the loss of data traffic from a wireless device.

With reference also to FIG. **5**, FIG. **5** is a general flowchart of operations for a channel changing methodology for an access point within a wireless network, according to one embodiment of the invention. Particularly, at Block **505**, client device traffic is monitored by the AP.

More particularly, at Block **510**, process **500** determines whether the amount of wireless device traffic from a wireless device for a particular channel is above a changing threshold. If so, at Block **515** channel changing is stopped. In one embodiment, the changing threshold may be at least one frame of wireless device traffic received from a client device within approximately one minute. In this way, if there has been any significant amount of wireless device traffic received from a client on this channel during this period of time, it is indicative that more traffic may be received from this wireless device such that it is more efficient to stop channel changing.

However, if this threshold is not met, then the process **500** of the AP continues channel changing (Block **520**) and again monitors for client device traffic (Block **505**) and process **500** is reiterated.

By utilizing the above methodologies as set forth in processes **400** and **500** of FIGS. **4** and **5**, respectively, efficient channel scanning and changing methods for an AP are disclosed that are based on total traffic, the type of call, as well as power-save status, to indicate points at which channel scanning and changing are not efficient for the wireless network. At these points, channel scanning and changing are stopped. In this way, the overall efficiency of the network is increased

because channel scanning and changing are stopped at points that may result in a significant increase in the probability of lost data traffic.

While the invention has been described in terms of several embodiments, the invention should not limited to only those embodiments described, but can be practiced with modification and alteration within the spirit and scope of the appended claims. The description is thus to be regarded as illustrative instead of limiting.

The invention claimed is:

1. A computer-implemented method, comprising:
   receiving, by a network device, wireless frames associated with a client device on a wireless network over a channel;
   monitoring, by the network device, the wireless frames, wherein monitoring includes tracking information about the wireless frames;
   halting, by the network device, channel scanning operations when one or more wireless frames indicate that the client device is in a power-save mode; and
   continuing, by the network device, the channel scanning operations when one or more wireless frames indicate that the client device is not in the power-save mode.

2. The method of claim **1**, wherein the information includes data corresponding to a channel used to transmit the wireless frames.

3. The method of claim **1**, wherein the information includes data corresponding to which wireless frames are an associated group.

4. The method of claim **1**, wherein the information includes data corresponding to the number of wireless frames within an associated group.

5. The method of claim **1**, wherein the information includes data corresponding to wireless frame types.

6. The method of claim **1**, wherein the information includes data corresponding to an operating status of a source of the wireless frames.

7. The method of claim **1**, wherein the channel scanning operations include listening for probe messages.

8. The method of claim **1**, wherein the channel scanning operations include changing between two or more available channels.

9. The method of claim **1**, further comprising:
   switching to a channel that the one or more wireless frames were transmitted on.

10. The method of claim **1**, further comprising:
    determining, by the network device, whether an amount of wireless frames being transmitted over a channel within a time period is greater than a threshold; and
    halting, by the network device, the channel scanning operations in response to a determination that the amount of wireless frames being transmitted over the channel within the time period is greater than the threshold.

11. The method of claim **1**, further comprising:
    determining, by the network device, whether the wireless frames are a predetermined type of communication; and
    halting, by the network device, the channel scanning operations in response to a determination that the wireless frames are the predetermined type of communication.

12. The method of claim **11**, wherein the predetermined type of communication is a voice call.

13. A network infrastructure device comprising:
    one or more processors;
    a non-transitory computer-readable medium containing instructions that, when executed by the one or more processors, cause the one or more processors to perform operations including:

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receiving wireless frames associated with a client device on a wireless network;

monitoring the wireless frames, wherein monitoring includes tracking information about the wireless frames;

halting channel scanning operations when one or more wireless frames indicate that the client device is in a power-save mode; and

continuing channel scanning operations when one or more wireless frames indicate that the client device is not in the power-save mode.

14. The device of claim 13, wherein the information includes data corresponding to a channel used to transmit the wireless frames.

15. The device of claim 13, wherein the information includes data corresponding to which wireless frames are an associated group.

16. The device of claim 13, wherein the information includes data corresponding to the number of wireless frames within an associated group.

17. The device of claim 13, wherein the information includes data corresponding to wireless frame types.

18. The device of claim 13, wherein the information includes data corresponding to an operating status of a source of the wireless frames.

19. The device of claim 13, wherein the channel scanning operations include listening for probe messages.

20. The device of claim 13, wherein the channel scanning operations include changing between two or more available channels.

21. The device of claim 13, further comprising instructions that cause the one or more processors to perform operations including:

switching to a channel that the one or more wireless frames were transmitted on.

22. The device of claim 13, further comprising instructions that cause the one or more processors to perform operations including:

determining whether an amount of wireless frames being transmitted over a channel within a time period is greater than a threshold; and

halting the channel scanning operations in response to a determination that the amount of wireless frames being transmitted over the channel within the time period is greater than the threshold.

23. The device of claim 13, further comprising instructions that cause the one or more processors to perform operations including:

determining whether the wireless frames is a predetermined type of communication; and

halting the channel scanning operations in response to a determination that the wireless frames are the predetermined type of communication.

24. The device of claim 23, wherein the predetermined type of communication is a voice call.

25. A computer-program product tangibly embodied in a non-transitory machine-readable storage medium of a network device, including instructions to cause one or more processors of the network device to:

receive wireless frames associated with a client device on a wireless network;

monitor the wireless frames, wherein monitoring includes tracking information about the wireless frames;

halt channel scanning operations when one or more wireless frames indicate that the client device is in a power-save mode; and

continue the channel scanning operations when one or more wireless frames indicate that the client device is not in the power-save mode.

26. The computer-program product of claim 25, wherein the information includes data corresponding to a channel used to transmit the wireless frames.

27. The computer-program product of claim 25, wherein the information includes data corresponding to which wireless frames are an associated group.

28. The computer-program product of claim 25, wherein the information includes data corresponding to the number of wireless frames within an associated group.

29. The computer-program product of claim 25, wherein the information includes data corresponding to wireless frame types.

30. The computer-program product of claim 25, wherein the information includes data corresponding to an operating status of a source of the wireless frames.

31. The computer-program product of claim 25, wherein the channel scanning operations include listening for probe messages.

32. The computer-program product of claim 25, wherein the channel scanning operations include changing between two or more available channels.

33. The computer-program product of claim 25, further comprising instructions to cause the one or more processors to:

switch to a channel that the one or more wireless frames were transmitted on.

34. The computer-program product of claim 25, further comprising instructions to cause the one or more processors to:

determine whether an amount of wireless frames being transmitted over a channel within a time period is greater than a threshold; and

halt the channel scanning operations in response to a determination that the amount of wireless frames being transmitted over the channel within the time period is greater than the threshold.

35. The computer-program product of claim 25, further comprising instructions to cause the one or more processors to:

determine whether the wireless frames is a predetermined type of communication; and

halt the channel scanning operations in response to a determination that the wireless frames are the predetermined type of communication.

36. The computer-program product of claim 35, wherein the predetermined type of communication is a voice call.

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